

Development of Low Cost Underwater Navigation Systems

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LONG-TERM GOAL

The long term goal of this work is to further the technology of autonomous underwater systems for minefield reconnaissance / mapping / neutralization..

OBJECTIVES

This particular project is aimed at improvements to low cost navigation systems using COTS equipment using extended Kalman filtering and sensor bias learning and compensation. Other related work includes the study of autonomous fault detection and compensation, as well as sea state learning for use in motion planning and oceanographic survey.

APPROACH

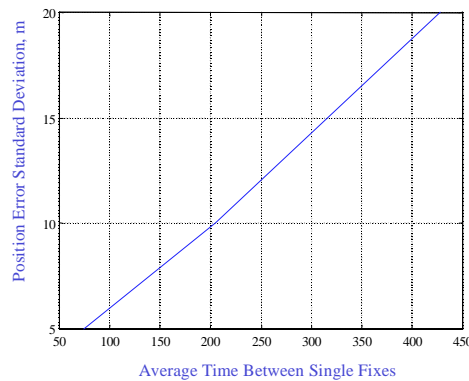
Working with the Florida Atlantic University and their Ocean Explorer Vehicle, the joint investigators have conducted a series of survey runs designed to illustrate the errors produced in navigation with dead reckoning. The system employs a triaxial magnetometer for compass heading, an Acoustic Doppler to measure speed over the ground. In theory, with perfect measurement, the velocities rotated into navigation coordinates may be integrated on line to provide the vehicle with knowledge of its position. With sensor errors these systems degrade and to achieve a one percent of distance travelled error compass heading should be accurate to within a degree. The errors in compass heading are critical to precision in navigation of these small vehicles, so the fusion of information from other sources such as DGPS / LBL / USBL sensors is needed.

WORK COMPLETED

Experimental results for a variety of runs have been obtained. Compass bias has been learned and precompensated using a 'deviation table'. This alone is not sufficient, and we have developed an extended Kalman filter to identify residual bias in the system. This residual bias has been found to be variable - unfortunately. It varies with true heading in a periodic fashion, and appears to be not predictable. A new system has been devised in which occasional surfacing is suggested to take Differential GPS fixes. Bias correction from a single fix is possible. Using a few single fixes, path errors are bounded, and for the results obtained, times between successive fixes lie between 75 and 400 seconds.

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A summary of the average time between fixes is a function of the error covariance (converted to standard deviation) as given in the figure below.



IMPACT/APPLICATION

Navigation of underwater platforms is critical to survey and mapping work. Low cost systems are also essential to the Navy's future. While precision navigation may be solved for large submarines, low cost units will have to rely on less accurate sensors and ways of fusing information from a variety of sources to maximize the achievable accuracy will be important.

TRANSITIONS

This work transitions into Ocean Sampling Systems using low cost AUVs, and to Models for VSW Minefield Simulation technology.

RELATED PROJECTS

1 – This work is leveraged from ONR funded work in Fault detection and Compensation, and from ONR work funding the Modeling and Simulation of Multi Robot Systems performance in UXO clearance.

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